Section 1
Introduction

In the early 1970's, the United States Air Force (USAF) developed a damage tolerance philosophy to help eliminate the type of structural failures and cracking problems that had been encountered on various military aircraft. Air Force review of structural failures had revealed that the safe life philosophy did not protect against designs that were intolerant to defects that could be introduced during manufacturing or during in-service use. From the standpoint of flight safety, it was found prudent to assume that new airframe structures could contain initial damage (e.g. scratches, flaws, burrs, cracks, etc) and that not all cracks would be found during inspections of older airframes. Accordingly, a damage tolerance philosophy was formulated based on the demonstration of structural safety under the assumption that pre-existing damage would be present at critical locations of all structurally significant details. The intent was to ensure that the maximum possible initial damage would not grow to a size that would endanger flight safety during the service life of the aircraft. Damage tolerance was formally adopted by the Air Force as part of the Airplane Structural Integrity Program (ASIP) [MIL-STD-1530, 1972] and was implemented originally through MIL-A-83444, Airplane Damage Tolerance Requirements. The Air Force now implements damage tolerant design through the recommended practices of the Department of Defense Joint Services Specification Guide, JSSG-2006 [1998].

The primary purpose of this handbook document is to provide guidelines and state-of-the-art analysis methods that should aid engineering personnel in complying with the intent of the USAF Airplane Damage Tolerant Guidelines for metallic structures. A secondary purpose is to provide specific background data and justification for the detailed guidelines. The handbook has been structured to provide a clear and concise summary of the Damage Tolerant Requirements and the supporting data and rationale behind the critical assumptions. Where appropriate, analysis methods, test techniques, and NDI methods are provided with suggested and/or recommended practices, limitations, etc. so stated. In the Handbook, pertinent paragraphs of JSSG-2006 will be referenced.

The remaining subsections of Section 1 provide:

a) an historical perspective on the evolution of the Air Force approach to structural integrity;

b) an overview of the Air Force Aircraft Structural Integrity Program as implemented through MIL-HDBK-1530;

c) an overview of USAF damage tolerance design guidelines as specified in the Joint Service Specification Guide (JSSG-2006); and,

d) an overview of sustainment in aging aircraft.

The topics covered in Sections 2 through 11 are given in Table 1.0.1. Relevant sample problems are presented in each Section. Additional sample problems are included in the Sample Problem section of the Handbook. For the convenience of the user, links to the appropriate USAF structural specifications are contained as an Appendix to this handbook. Any conflict or discrepancy in information contained in this handbook and/or the Joint Service Specification

Guide is unintentional and in all cases, the governing document is the current version of the Guide.

This new version of the Handbook is presented as a web-based document, allowing easy access for all users from any location. The web page will allow timely updates as new methodologies emerge and technologies advance. Finding information will be easier with the search capabilities available in electronic documents. Hyperlinks are provided for sub-sections, figures, tables, and references within the handbook, as well as to other related web sites. Links are provided to websites where referenced papers can be found, software can be downloaded, and additional in-depth information is provided. Advantages of this are to give the user the most accurate, up-to-date information without reprinting the Handbook.

In addition to the web pages, each Section of the Handbook, as well as the Sample Problems, is available as a file in .pdf format, that can be downloaded and printed.

Table 1.0.1. Summary of Sections of Damage Tolerance Design Handbook

Section	Title	Description
2	Fundamentals of Damage Tolerance	Basic elements of the methodology for damage tolerant analysis.
3	Damage Size Considerations	Appropriate NDI practice, state-of-the-art procedures, demonstration programs to qualify NDI, in service NDI practice and specific examples illustrating how damage is assumed to exist in structures.
4	Residual Strength	Theory, methods, assumptions, material data, test verification, and gives examples for estimating the final fracture strength or crack arrest potential of cracked structures.
5	Analysis of Damage Growth	Current practice for estimating the rate of crack growth as a function of time, cyclic and sustained load occurrence; gives examples indicating limitations of methods, use of material data and suggested testing to support predictions and establish confidence.
6	Example Damage Tolerance Analyses	Detailed analysis of typical structural examples illustrating methodology and assumptions required.
7	Damage Tolerance Testing	Methods and recommended tests to verify methods, full-scale testing to verify residual strength and slow crack growth rates.
8	Force Management/ Sustainment Engineering	Force structural maintenance (FSM) planning and methods available to account for usage variations for individual aircraft based on a crack growth model.
9	Structural Repairs	Factors that should be considered when designing a repair, in order to ensure that the basic damage tolerance present in the original structure is not degraded by the repair.
10	Guidelines for Damage Tolerant Design and Fracture Control Planning	Methods and procedures for development and implementation of a damage tolerance control plan as required in MIL-HDBK-1530.
11	Summary of Stress Intensity Factor Information	Stress intensity factors